2.4m Space Telescopes

Hardware Summary

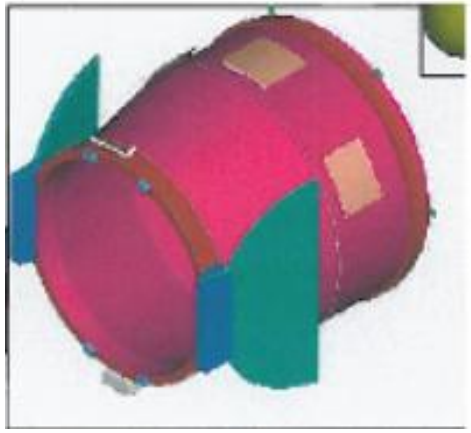
September 4, 2012

Hardware Summary

- Available Flight Hardware
  - Two, 2.4m, two-mirror telescopes
    - One completed with full thermal hardware
    - Electronics & Actuators have been harvested but can be rebuilt to existing drawings
  - Two outer barrel assemblies
    - One fully completed with thermal blankets and butterfly doors
  - One hardware radiator/electronics bays
    - Aluminum structures for radiator and electronic attachment
    - Acted as a “spacer” between the spacecraft and the outer barrel assembly
- All ground support equipment for alignment, integration, and test
- Miscellaneous parts for a third system

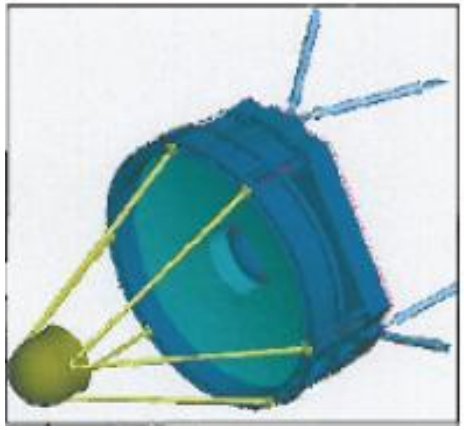
Robust traceability has been retained for all flight hardware

Hardware



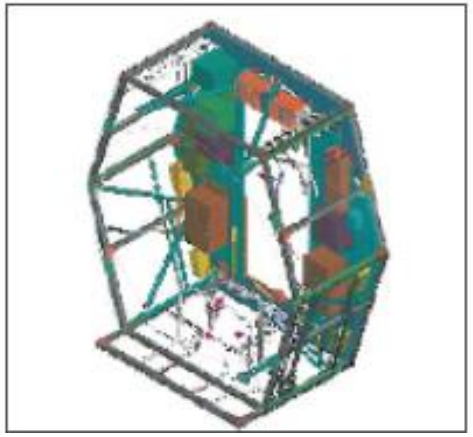
Outer Barrel Assembly (OBA)

2 Assemblies Available



Telescope Subsystem (TSS)

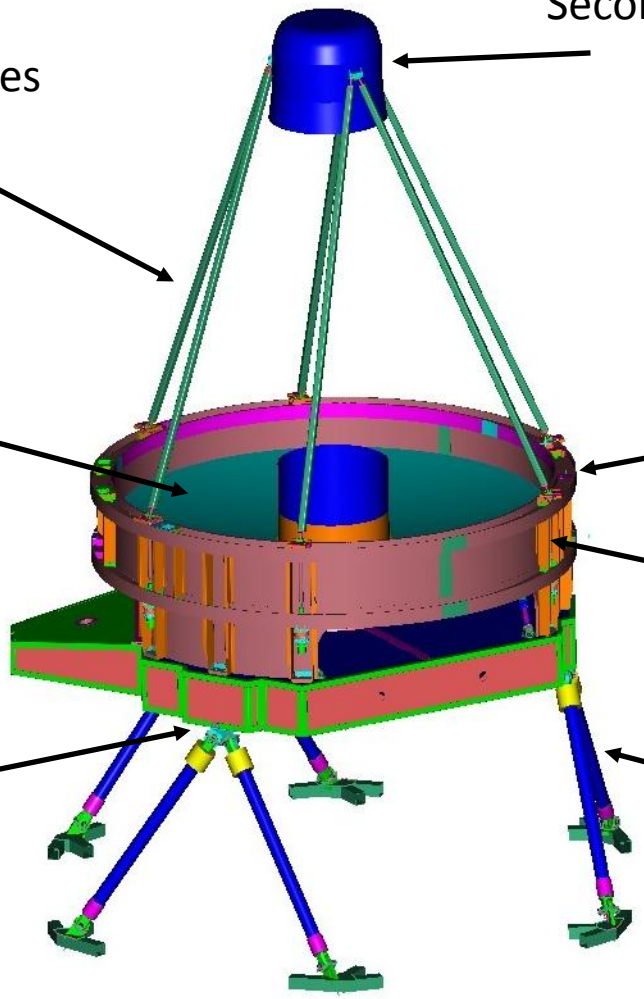
2 Assemblies Available



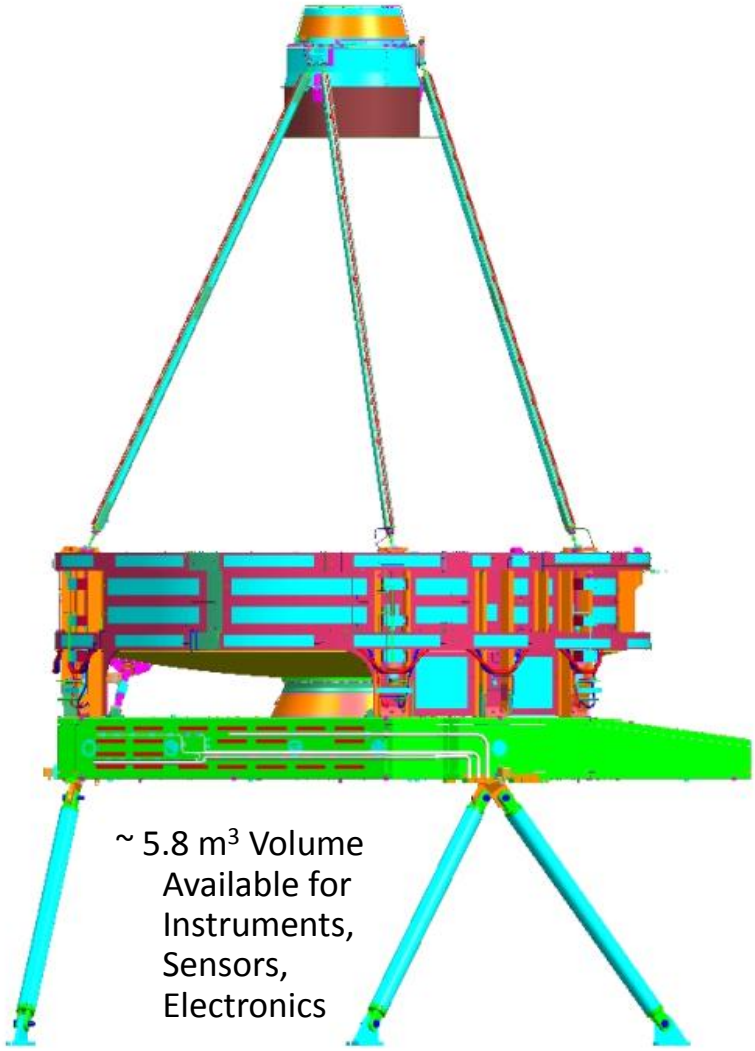
Payload Radiator Subsystem (PLRSS)

1 Assembly Available

Forward Optics Assembly (FOA) Configuration



2.4m Space Telescope Form

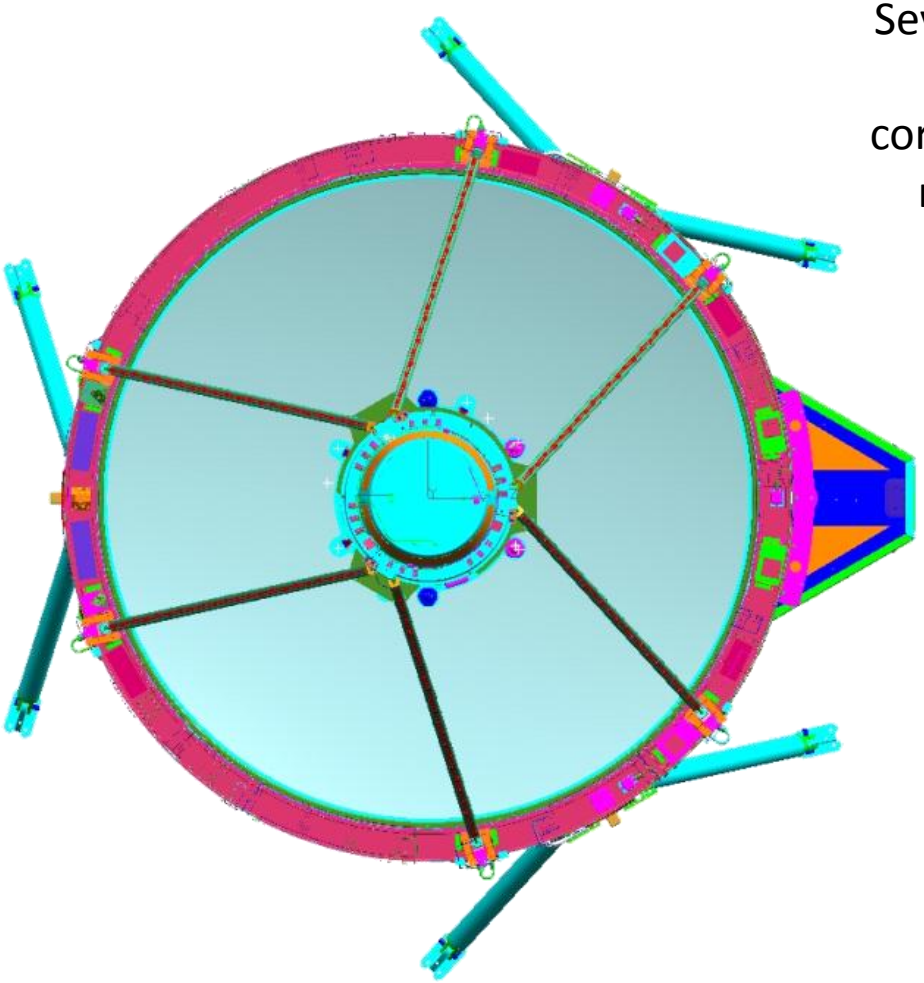


- **Optical Form: 2 Mirror, f/8**
- **Aperture: 2.37m**
- **Unvignetted Field of View: ~ 1.8^0 Dia.**
- **Wavefront Quality: <60 nm rms**
- **Secondary Mirror Assembly Control –**
  - **6 DOF plus fine focus**
  - ***6 DOF Actuators are at the base of the secondary struts***
  - ***Focus actuator is behind the SMA***
- **Mass: 840kg**
- **Back Focus: 1.2m behind PM Vertex**

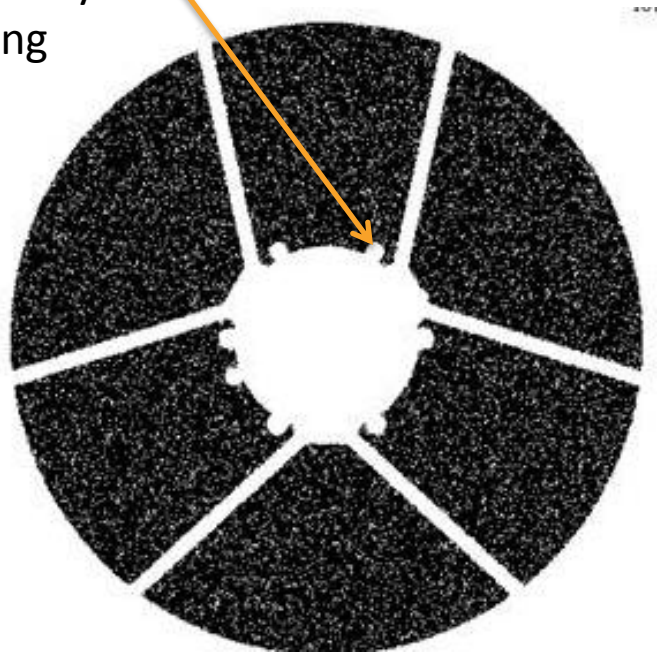
Outer Barrel Assembly

- **Thermal Protective Enclosure *including Two Actuated Thermal Butterfly Doors***
- **Composite Structure**
- **Full MLI blanket set also completed**
- **Mass: 280kg (without blankets)**
- **Mounting: Requires Interim Structure connected to Spacecraft Interface**

System Obstruction



Seven coating artifacts correctable by recoating



On Axis Pupil

17% Obstructed

Strut Mean Width: 41mm

Strut Obstruction Length: 881mm

Mirror Quality and Coating

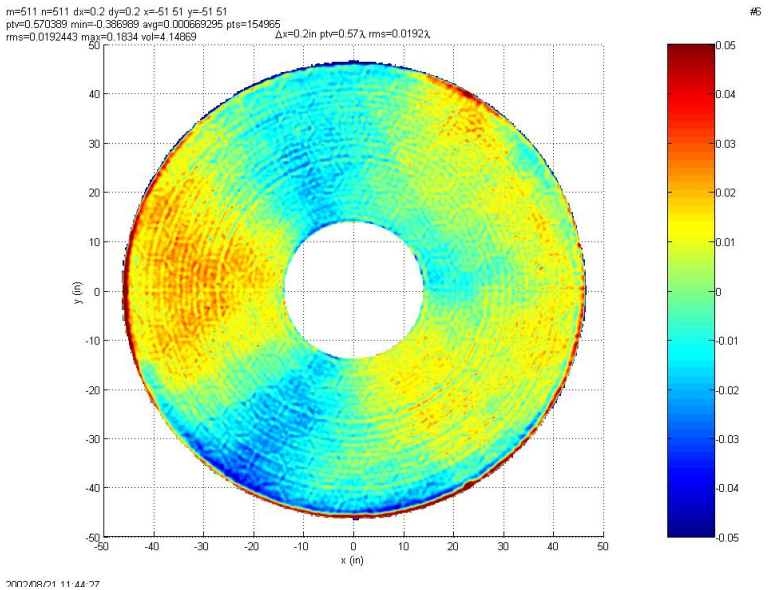
Primary Mirror (~40kg/m²)

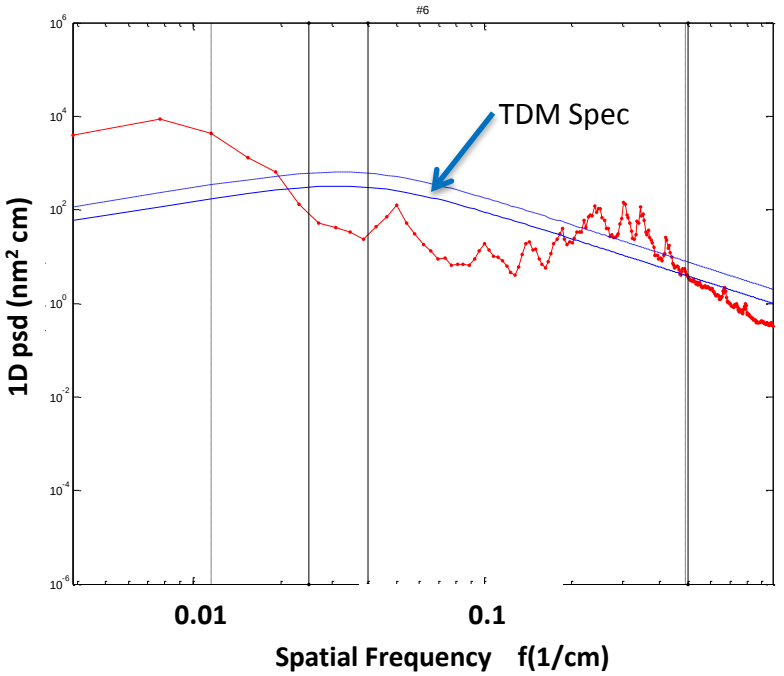
Clear Aperture: 2.37m OD, 0.7m ID

Form: Concave, F/1.2

Surface Quality: 12nm RMS

Mirror Coating: Protected Silver





2 Dimensional Average PSD

Secondary Mirror

Clear Aperture: 0.53m OD, 0.02m ID

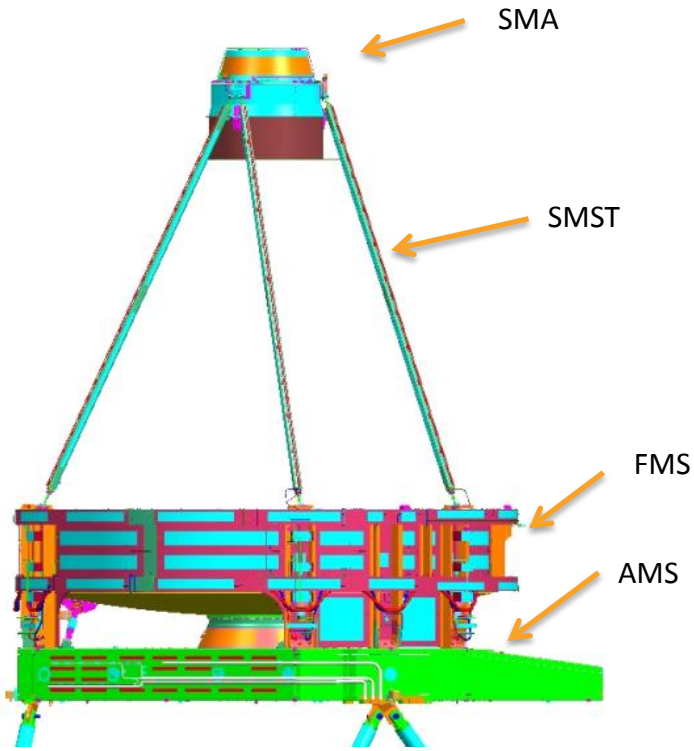
Form: Convex

Surface Quality: 16nm rms

Mirror Coating: Protected Silver

Telescope Thermal Configuration

- **Cold biased design - Outer Barrel Assembly (OBA) serves as a passively cooled radiative enclosure to attenuate environment changes.**
- **Heaters control telescope: Aft Metering Structure (AMS), Forward Metering Structure (FMS), Secondary Mirror Assembly (SMA), Secondary Mirror Support Tubes (SMST)**
  - **Minimize radial and diametrical gradients near PMA**
  - **Independent prime, redundant, and survival heaters**
  - **Control telemetry for each heater zone**
  - **Prime & redundant for computer-based control**
  - **Autonomous hybrid heater controllers (HHC) for survival**
  - **OBA heater control located on door mechanism only**
- **MLI on FMS, SMA, OBA OD, SMST surfaces away from PM**



Heater Zones by Region (Prime Side Only)

Heater Location	# of Zones	Capacity (Watts)
AMS	24	102
FMS	21	100
SMST	12	106
SMA	5	25

ITT Exelis State of the Art Material Technology Utilized to Provide Stable Telescope

Hybrid Laminates with low CTE, low CME, and high modulus *(patented)*

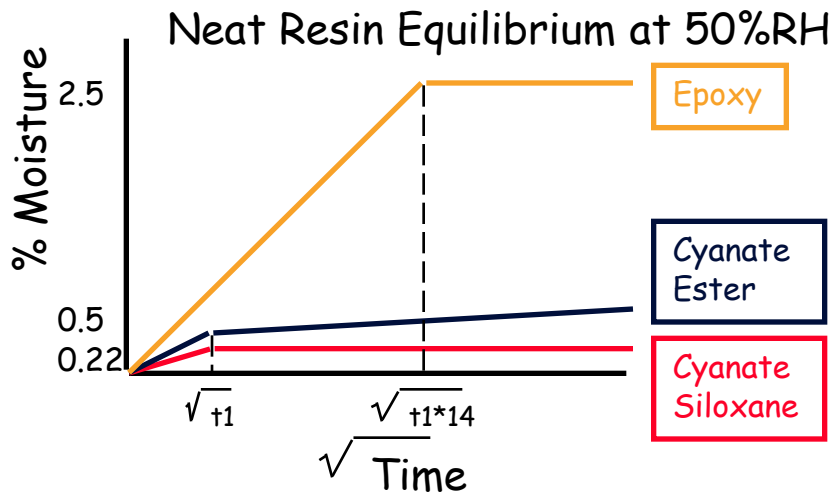
- 0 CTE (0.0 ± 0.1 µin/in°F) in all inplane directions

Cyanate Siloxane Resin with low moisture uptake *(ITT/Hexcel development)*

Hygro strain
< 15 µin/in

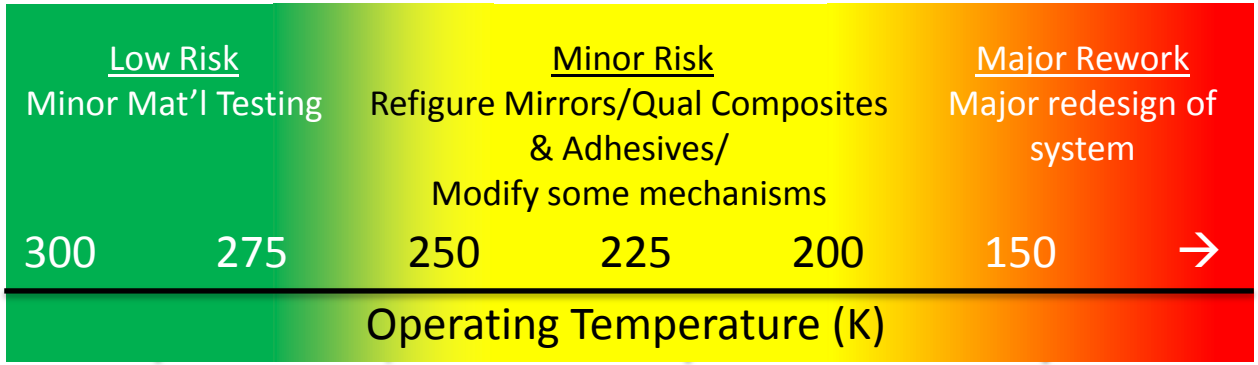
Invar Fittings where required for stability

- CTE: < 0.4 µin/in°F
- Temporal Stability (Invar growth): < 2 ± 1 µin/in/yr



Thermal Operating Considerations

- Telescope system was designed to operate around 293K (Room Temperature)
  - Does not require requalification for warm launch
- Various material considerations influence using the system at colder temperatures
  - Mirror Materials
    - Corning ULE™ is optimized for room temperature applications
    - ULE™ has been tested at 20K with degraded CTE characteristics
  - Structures
    - Laminate also optimized for room temperature use
    - CTE characteristics degrade slowly so some level of off-nominal conditions would be acceptable
  - Bonding Materials
    - GE RTV-566 used to attach mirrors to mounts would need qualification at off-nominal temperatures
  - Mechanisms
    - Precision mechanisms would be a concern



Summary

- Telescope system designed for room temperature operation
  - Off optimal thermal configuration is possible with some level of analysis and retest
  - We do not recommend operating temperatures below 200K due to numerous material, electronic, and optical considerations
- Some minor rework on the telescope is very low risk
  - Telescopes were designed to be taken apart and refurbished
  - Ion figuring and recoating would be considered very low risk for example
- Instrument section is the most doubtful of the configuration
  - Aluminum and heavy
  - Designed for a specific instrument accommodation
  - Not a cost driver to replace with a better form factor
- Outer Barrel Assembly is probably shorter than desired for NASA mission
  - Extension and repositioning is low cost and low risk
- Point of Contact

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